View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Research Papers in Economics

"To R&D or not to R&D, that is the Question": A Firm Level Study of Employment Growth in the Irish Manufacturing Sector, 1986-95.

JEL Classifications J23, O32 & O33

September 1997

Frances Ruane
Department of Economics
Trinity College
Dublin 2.
email: fruane@tcd.ie

Allan Kearns
Department of Economics
Trinity College
Dublin 2.
email: kearnsa@tcd.ie

Abstract

This paper uses micro-data to examine the relationship between R&D activity and employment growth. The R&D and employment data used are drawn from a survey of the Irish manufacturing sector undertaken by Forfás, the policy and advisory board for industrial development in Ireland. By international standards, Ireland has an exceptionally high level of foreign direct investment (FDI) and the paper explores differences in the R&D/growth relationships between foreign and indigenous firms, exploring the incidence and scale of R&D activity. Our preliminary findings of superior net employment creation for R&D-active firms, combined with the superior performance of the high tech sector, are bench marked against a number of similar studies.

Acknowledgements

We gratefully acknowledge the provision of data for this study by Forfás and the help given by Marcus Breathnach and his colleagues in the Science & Technology Division in the preparation of this paper. We are grateful to Holger Görg for helpful comments.

I Introduction

Following a period of recession, the Irish economy has enjoyed significant growth over the past decade, earning Ireland its "Celtic Tiger" nickname. This growth, both in employment and output terms, is most marked in the manufacturing sector. The contrast in employment growth is primarily with EU countries, which have seen employment in manufacturing rise by 0.5[1] per cent since 1986, while employment in the Irish manufacturing sector during the same period has risen by 5.4 per cent.[2] A key feature of Ireland's growth has been the expansion of foreign-owned (FDI) plants which now account for 23 per cent of total manufacturing firms in the country and 46.5 per cent of manufacturing employment.[3] The growth in employment has been concentrated in the high tech sectors, where employment has more than doubled since 1986; these sectors now account for 31 per cent and 4.4 per cent of total manufacturing employment in foreign and Irish-owned firms respectively.

The rapid growth in employment in these sectors has given rise to an increased interest in the relationship between technology and employment growth in Ireland. The issue arises as to whether the growth is simply related to the ***sectors*** in which investment in technology is taking place or whether or not the technological performance of ***individual firms*** is a significant contributory factor. In particular, an important question is whether the firms which are growing most rapidly are those which are engaging in research and development (R&D).

This paper presents some very preliminary results of the analysis of a data set which allows us for the first time to compare the employment performances of firms which are and are not engaging

[1] Eurostat (1997) *Eurostatistics*, 6/1997, Eurostat (1991) *Eurostatistics*, 12/1991.
[2] Employment growth rates in the US and Canadian manufacturing sectors in the same period were 6.2 per cent and 7.5 per cent respectively. (OECD 1996)
[3] The latest output data available (1993), show that output of foreign owned manufacturing firms accounts for 68.4 per cent of total manufacturing output.

in R&D in Ireland.[4] Studies of this topic in other countries typically look at ***all*** firms operating in the economy. [5] In the Irish context we believe that it is important for several reasons not to aggregate foreign and domestic firms. Firstly, as pointed out elsewhere, there are significant differences between foreign and domestic firms with regards to size, market orientation, etc.[6] Secondly, it is not generally meaningful to try to relate R&D expenditures undertaken by FDI firms in the host country to employment growth in the host country, in the same manner as one might for domestically-owned firms, since FDI firms will typically benefit from current R&D expenditures in the home country or in other host countries[7] and indeed from the firm's world-wide "knowledge stocks".[8] However, it is of significant policy concern whether or not FDI firms which engage in R&D in the host country tend to grow faster in employment terms than those which do not. In this paper we look at foreign[9] and indigenous manufacturing industry separately and focus on R&D activity and employment growth and on the differences in R&D scale measures.

II Overall Employment Growth and R&D Activity

[4] The data set explored here is a unique combination of two sources. The R&D data are drawn from a survey of R&D performing firms, undertaken by the policy and advisory board for industrial development in Ireland (Forfás). This organisation has statutory responsibility for R&D statistics in Ireland. For the years 1986 to 1993, the biannual surveys reported data on the population of R&D performers in the manufacturing and internationally-traded services sectors. The employment data are drawn from the annual employment surveys undertaken by the same agency. Similarly to the R&D data, these employment surveys cover the population of firms in the manufacturing and internationally traded service sectors. The employment data for this study have been subdivided to include every firm with ten or more employees in each year 1986 to 1995. Thus the basis of our comparison for the years 1986 to 1995 is the population of firms with ≥ 10 employees against the population of R&D performing firms (≥10 employees). This allows us to identify the population of non-R&D performing firms, with ten or more employees for the period 1986 to 1995. (These data differ from those used by Eurostat and the OECD which include firms with less than ten employees.)

[5] See Van Reenen (1997) for the United Kingdom; Vivarelli et al (1996) for Italy; Costas Meghir et al (1995) for the UK; Klette & Forre (1995) for Norway; Leo & Steiner (1995) for Austria.

[6] See Ruane and Goerg (1997).

[7] Conversely, the FDI subsidiary may be undertaking R&D in the host country which generates employment in other countries, including the home country, where the company has plants.

[8] This would be particularly the case for many of the major companies investing in Ireland over the past decade, such as Intel, Microsoft, IBM, etc.

[9] According to Forfás, a firm is classified as foreign-owned when 50% + equity is held by non-Irish resident(s).

Table 1 shows that the number of Irish manufacturing firms (employing ten or more) grew by 1.1 per cent between 1986 and 1995, with a corresponding growth in employment of 2 per cent. However, the apparently modest growth in firm numbers and employment masks a much larger underlying dynamic.[10] Over 35 per cent of the firms which existed in 1986 had ceased production in 1995, while over 30 per cent of firms in 1995 (with greater than or equal to ten employees) did not exist in 1986. Gross job creation in Irish manufacturing firms during the period was 43,434 compared with a net employment change of a mere 2,133 jobs.

Table 1: Firm Numbers and Employment in Indigenous Industry, 1986-95

	Irish Manufacturing Firms					
	Number of firms			Employment		
YEAR	1986	1995	% Δ	1986	1995	% Δ
R&D Active	537	616	14.7	50861	54019	6.2
Non-R&D Active	1640	1585	-3.4	55427	54402	-1.9
Total	2177	2201	1.1	106288	108421	2.0

Table 1 distinguishes between firms which are and are not engaged in R&D. The definition of R&D used here is wide[11] and includes any firm which might reasonably have been assumed to be "R&D active". The sub-classification shows a marked contrast between the two groups of firms which is hidden by the aggregate change. Over the period the number of firms which were R&D active grew by almost 15 per cent while the number of non-R&D active firms declined by over 3 per cent, resulting in the share of R&D active firms increasing from 24.6 to 27.9 per cent over the period. It seems reasonable to assume that the growth in the R&D numbers arose in part from firms

[10] See Strobl & Walsh (1996)

[11] To be classified as R&D active, a firm needs to have reported R&D spend at least once over the period of our R&D surveys (1986-1993). We return to this issue of definitions below.

which were non-R&D active in 1986 becoming R&D active by 1995.[12] The corresponding employment growth was 6 per cent for firms engaged in R&D and a 2 per cent decline in employment in firms classified as non-R&D active - in effect the net job creation for Irish manufacturing firms is a result of the increase in employment of the R&D active firms (3,158 employees) more than offsetting the employment decline (1,025 employees) in the non-R&D performing firms. In tandem with the increasing share of R&D active firms in total firms, the share of employment in R&D active firms rose from 47.9 to 49.8 percent over the period.

Table 1 suggests that a superior employment performance is achieved by the subsection of Irish-owned firms which engages in R&D activity. The corresponding data for foreign companies, shown in Table 2, indicate that the number of foreign firms in the Irish manufacturing sector grew by 4.8 per cent between 1986 and 1995, with a corresponding growth in employment of nearly 24 per cent. Again, but to a lesser extent this is the case of indigenous industry, the net growth in employment of 18,142 jobs masks the more dramatic change associated with gross job creation of 42,736 during the period.

Table 2: Firm Numbers and Employment in Foreign Industry, 1986-95

	Foreign Manufacturing Firms					
	Number of firms			Employment		
YEAR	1986	1995	% Δ	1986	1995	% Δ
R&D Active	279	289	3.6	44440	54906	23.6
Non-R&D Active	341	359	5.2	31713	39389	24.2
Total	620	648	4.5	76153	94295	23.8

[12] The R&D surveys have been undertaken in 1986, 1988, 1990, 1991, 1993 and 1995. The 1995 R&D survey has been omitted due to a change in the methodology used by the surveyors. It is beyond the scope of this paper to incorporate this latest survey into the above analysis.

Once again we distinguish between foreign-owned firms which are and are not engaged in R&D. In contrast with the case of indigenous industry, the sub-classification shows a marked similarity between the two groups. Over the period the number of R&D active firms grew by 3.6 per cent while the non-active firms increased by 5.2 per cent. The corresponding employment growth was close to 24 per cent for both groups. In other words over 57 per cent of the 18,142 net jobs created over the period were in R&D active firms. The share of R&D active firms in total foreign firms which is almost double the corresponding share for indigenous firms, remained virtually unchanged over the period at around 45 per cent. Similarly, the share of total employment engaged in R&D active foreign firms remained unchanged (58 per cent).[13]

III Employment Growth and R&D: Cohort Analysis

The difficulty in interpreting Tables 1 and 2 is that one is not comparing the same set of firms in 1986 and 1995. As noted above, some firms which existed in 1986 did not survive to 1995 and similarly some of the firms included in the 1995 data did not exist in 1986. Furthermore, as the sectoral composition of Irish and foreign firms is not the same, there may be a significant sectoral explanation to the different employment experiences associated with R&D expenditures. In order to take account of the changes in firm numbers, both gross and net, and sectoral composition, we examine in Table 3 the cohort of firms which existed in 1986 and consider, at a fairly high level of sectoral aggregation, whether it is possible to discern any impact of the effect of engaging in R&D on employment in these firms. We have taken all firms that had employment greater with ten or more employees in 1986 and quantified the associated employment change, distinguishing according to whether they were R&D active or not over the period 1986 to 1993. We note that the non-R&D active firms are more heavily concentrated in the low-tech sectors than the R&D active firms - 75 per cent in the former with 55 per cent in the latter.

[13] The contrast between firm shares and employment shares across foreign and indigenous firms is due to the fact that the average employment size of R&D active firms is significantly greater than that of non-R&D active firms in the case of indigenous industry.

Table 3: Growth in Employment in 1986 Cohort of Irish-owned Firms

	Employment								
	Non R&D Active			R&D Active			Total		
YEAR	1986	1995	% Δ	1986	1995	% Δ	1986	1995	%Δ
High tech	595	510	-14.3	2765	2407	-12.9	3360	2917	-13.2
Med.-High tech	3770	2482	-34.2	4965	5753	15.8	8735	8235	-5.7
Med.-Low tech	9191	6962	-24.3	14757	11859	-19.7	23948	18821	-21.4
Low tech	41871	28490	-32.0	28374	28247	-0.5	70245	56737	-19.9
Totals	55427	38444	-30.6	50861	48266	-5.1	106288	86710	-18.4

Note first the contrast between the employment change in Tables 1 and 3. Whereas employment in Irish-owned manufacturing companies rose overall by 2 per cent between 1986 and 1995, employment in the existing set of firms fell by over 18 per cent. For this group (2,177 firms in total), those firms that did not engage in R&D suffered an aggregate employment loss of over 30 per cent compared with an employment loss of 5 per cent in R&D active firms. Using the standard OECD sectoral aggregation,[14] we find that in the case of non-R&D active firms there was a decline in employment in each sector and this decline was most marked in the medium-high tech and low tech firms. Among R&D active firms, employment grew significantly in the medium-high tech sector (the sector which suffered the highest rate of employment loss among non-R&D active firms) and the losses in the remaining sectors were lower than in their non-R&D counterparts.[15]

[14] The OECD sectoral classification is as follows: **High Tech**: Aerospace, Computers & Office machinery, Electronics & Communications, Pharmaceuticals; **Medium-High Tech**: Scientific Instruments, Electrical Machinery, Motor Vehicles, Chemicals, Non electrical machinery; **Medium-low Tech**: Shipbuilding, Rubber & plastic equipment, Other transport equipment, Stone, clay & glass, Non-ferrous metals, Other manufacturing, Fabricated metal products; and **Low Tech**: Petroleum refining, Ferrous metals, Paper printing, Textiles and clothing, Wood & furniture, Food beverages.
For the ISIC equivalent classification see Appendix B in Klette (1995).

[15] The low-tech sector accounted for approximately the same share of jobs in non-R&D firms in both 1986 and 1995, whereas the low-tech share in the R&D active firms actually increased.

Table 4: Growth in Employment in 1986 Cohort of Foreign Firms

Foreign	Employment								
	Non R&D Active			R&D Active			Total		
YEAR	1986	1995	% Δ	1986	1995	% Δ	1986	1995	% Δ
High tech	4831	2834	-42.4	9148	14055	53.6	13979	16889	20.8
Med.-High tech	8422	7856	-6.7	13186	16634	26.1	21608	24490	13.3
Med.-Low tech	5378	5381	0.0	6677	6449	-3.4	12055	11830	-1.9
Low tech	13082	7647	-41.6	15429	14547	-5.7	28511	22194	-22.2
Totals	31713	23718	-25.2	44440	51685	16.3	76153	75403	-1.0

A similar contrast is found between the employment change measures in Tables 2 and 4. Whereas employment in foreign-owned companies rose overall by almost 24 per cent between 1986 and 1995, employment in the existing set of firms actually fell by 1 per cent. For this group of firms (620 firms in total), those firms that did not engage in R&D suffered an aggregate employment loss of over 25 per cent, compared with an employment gain of over 16 per cent in R&D active firms. Looking at sectors, we find that in the case of non-R&D active firms there was no growth in employment in any sector. The decline in employment was most marked among high tech and low tech firms. Employment in R&D active firms grew significantly in the high tech (the sector which suffered the highest rate of employment loss among non-R&D active firms) and medium-high tech sector. The employment loss in R&D active firms in the low tech sector was much lower than in their non-R&D counterparts. Finally, we note that the share of jobs in the low tech sector was much higher for indigenous compared with foreign firms in 1986 (66 per cent with 37 per cent), and that over the period this sectoral concentration level remained almost unchanged for Irish owned companies while it fell further (to 29 per cent) for foreign companies.[16]

[16] As in the case of Irish firms, the low tech sector accounts for actually more jobs among foreign R&D firms compared with foreign non-R&D firms, though the difference is less marked.

IV Growth and R&D: Alternative Measures of R&D Activity

The evidence thus far suggests that the employment performance of R&D active firms is superior to that of non-R&D active firms. It could be argued that our definition of R&D active is rather minimalist and that a more precise definition is required. To take account of this we distinguish firms according to the scale of R&D expenditure, dividing them into high R&D spending and low R&D spending firms.[17] If our preliminary findings of a positive association between R&D activity and superior employment performance carry through, then we could expect that high spending firms perform better in employment terms. Tables 5 and 6 present our findings for the cohort of Irish and foreign-owned firms respectively.

Table 5: Absolute employment change for Irish Non R&D and R&D Spenders for the Cohort.

Irish	Absolute employment change for Non R&D and R&D Spenders for the Cohort.								
	Small R&D Spenders			**Large R&D Spenders**			**Total R&D Active**		
YEAR	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**
High tech	942	678	-28.0	1823	1729	-5.2	2765	2407	-12.9
Med.-High tech	1903	1901	-0.1	3062	3852	25.8	4965	5753	15.8
Med.-Low tech	4263	4285	0.5	10494	7574	-27.8	14757	11859	-19.7
Low tech	9385	8373	-10.8	18989	19874	4.7	28374	28247	-0.5
Totals	16493	15237	-7.6	34368	33029	-3.9	50861	48266	-5.1

As noted above the decline in employment for all Irish R&D active firms was over five percent. This decline though was relatively less for the high R&D spending firms in every sector except the medium-low tech sector. Overall the percentage decline in employment for the high R&D firms in the cohort was 3.9 percent as opposed to 7.6 percent for the low R&D spending firms, and 30.6 percent for the non-R&D active firms.

[17] A high R&D spending firm spent £100,000 punts (Irish pounds) or more over the period 1986 to 1995. A low R&D spending firm spent less than this amount.

Table 6: Absolute employment change for foreign-owned Non R&D and R&D Spenders for the Cohort.

Foreign	Absolute employment change for Non R&D and R&D Spenders for the Cohort.								
	Small R&D Spenders			**Large R&D Spenders**			**Total R&D Active**		
YEAR	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**
High tech	557	820	47.2	8591	13235	54.1	9148	14055	53.6
Med.-High tech	1871	2147	14.8	11315	14487	28.0	13186	16634	26.1
Med.-Low tech	2454	2100	-14.4	4223	4349	3.0	6677	6449	-3.4
Low tech	2928	2156	-26.4	12501	12391	-0.9	15429	14547	-5.7
Totals	7810	7223	-7.5	36630	44462	21.4	44440	51685	16.3

The equivalent figures for the foreign-owned firms confirm our expectation that the employment performance is better for the high R&D spending firms. The employment change (increase) for high R&D spending firms is 21 percent, comparing favourably to an employment decrease of over 7 percent for low R&D spending firms and over 25% decline for non-R&D active firms.

V Firm Exit Rates and Employment Performance of Surviving Firms

Thus far we have taken our cohort of 1986 firms and quantified their net job creation over the period 1986 to 1995. However we have made no distinction between those firms in the cohort that exited[18] over this period and the balance of the firms that survived. There are three specific questions that can now be asked for our cohort. Can we expect that there was greater firm exit for (1) firms in low technology sectors relative to higher technology sectors, (2) for non-R&D active firms as opposed to R&D active firms, and finally, (3) for small R&D spending firms relative to high R&D spending firms. Tables 7 and 8 show the percentage of firms that have exited from the cohort. [19]

[18] To exit, a firm must report employment of less than ten employees in 1995. Our dataset is the population of manufacturing firms with ten employees or more.

Table 7: Percentages of Irish Firms exiting

Irish	Percentage of firm Exit by Sector and R&D Activity				
	Non R&D Active	**Total R&D Active**	**Small R&D Spenders**	**Large R&D Spenders**	Total
YEAR	**% Δ**	**% Δ**	**% Δ**	**% Δ**	**% Δ**
High tech	-38.9	-28.6	-33.3	-26.7	-31.7
Med.-High tech	-53.8	-21.4	-22.4	-20.0	-41.0
Med.-Low tech	-37.4	-17.8	-23.1	-7.4	-31.4
Low tech	-47.5	-14.2	-16.2	-10.5	-41.7
Totals	-34.5	-17.7	-20.2	-14.0	-31.2

Table 8: Percentages of Foreign-owned Firms exiting

Foreign	Percentage of firm Exit by Sector and R&D Activity				
	Non R&D Active	**Total R&D Active**	**Small R&D Spenders**	**Large R&D Spenders**	Total
YEAR	**% Δ**	**% Δ**	**% Δ**	**% Δ**	**% Δ**
High tech	-43.6	-9.7	-18.2	-7.8	-22.8
Med.-High tech	-27.0	-16.7	-10.3	-4.5	-16.2
Med.-Low tech	-30.7	-6.6	-12.5	0.0	-20.8
Low tech	-46.4	-16.7	-29.6	-6.1	-36.8
Totals	-37.0	-9.7	-18.2	-5.0	-24.7

The sectoral pattern of firm exits is similar for both the Irish and foreign-owned firms. If we consider all firms, irrespective of their scale of R&D activity, we find a higher percentage of firm exit in the low tech sector than that experienced in the high-tech sector. For foreign firms, almost 23 percent of firms exited in the high tech sector which compares favourably with almost 37 percent exiting in the low tech sector, the corresponding exit rates for indigenous firms are 32 and 42 percent respectively.

[19] Care should be taken in interpreting percentage changes. In some cases the number of firms is very small. For this purpose extended versions of these tables are placed in Appendix A. They include the absolute numbers that gave rise to these percentage changes.

In terms of a pattern of firm exit for R&D spending firms relative to non-R&D active firms, we see that almost 35 percent of Irish non-R&D spending firms exited from the cohort over the period - almost double the corresponding percentage for R&D spending firms. The gap is wider if one considers foreign firms - 37 per cent of non-R&D spending foreign firms exited from the cohort, compared with less than 10 percent for R&D active firms.

The final distinction to be made is between high and low R&D active firms. The number of high R&D spending firms exiting from the cohort is less than the observed number of low R&D spending firms. This result applies regardless of the sector chosen or the nationality of ownership.

The final stage of analysis for the cohort is the employment performance of those firms that survived.[20] We are interested in the difference in employment performance by sector, R&D activity and scale of R&D activity. Tables 9 and 10 present our findings for Irish and foreign-owned firms respectively.

Table 9: Percentage Employment Increases for the Surviving Irish firms

Irish	Percentage Employment Increases for the Surviving firms in the Cohort				
	Non R&D Active	**Total R&D Active**	**Small R&D Spenders**	**Large R&D Spenders**	**Total**
YEAR	**% Δ**	**% Δ**	**% Δ**	**% Δ**	**% Δ**
High tech	57.7	19.8	-4.4	33.1	25.0
Med.-High tech	16.7	47.6	56.5	43.7	37.2
Med.-Low tech	13.5	-15.5	17.9	-27.1	-6.8
Low tech	5.6	9.9	5.7	11.8	7.7
Totals	8.1	5.7	13.0	2.7	6.8

The employment change for surviving Irish firms is greater for the higher technology sectors than the lower technology sectors. However, our expectations of a positive association between superior employment performance and R&D activity do not appear to apply in this case. In the

[20] This is similar to the methodology adopted by Baldwin (1995) where his study is concerned only with growing firms - all firms in decline were excluded.

majority of the sectors, the employment performance of the non-R&D active firms is actually higher than that of the R&D spending firms. The respective employment growth rates are 8 percent for non-R&D firms and 5.7 percent for R&D firms. In a comparison of low and high R&D spending firms, the higher spending firms do not register a greater percentage employment change. This is contrary to the generally positive association between R&D expenditures and employment change that we have observed in looking at the total cohort. One possible explanation is that R&D activity helps a firm to survive, but that having survived R&D activity does not influence the extent to which a firm prospers.[21]

Table 10: Percentage Employment Increases for the Surviving foreign-owned firms

Foreign	Percentage Employment Increases for the Surviving firms in the Cohort				
	Non R&D Active	**Total R&D Active**	**Small R&D Spenders**	**Large R&D Spenders**	**Total**
YEAR	**% Δ**	**% Δ**	**% Δ**	**% Δ**	**% Δ**
High tech	9.9	61.3	93.6	59.6	49.6
Med.-High tech	3.2	30.7	23.8	31.7	20.4
Med.-Low tech	22.1	-1.0	-8.2	3.0	8.3
Low tech	-3.0	5.5	-12.8	9.5	2.4
Totals	5.5	23.8	4.4	27.7	17.4

In contrast to the ambiguous situation for the Irish surviving firms in the cohort, a superior employment performance is found in the foreign-owned firms for (1) higher technology sectors compared to lower technology firms, (2) in the majority for non-R&D spending relative to R&D spending firms, and finally (3) in the majority for high R&D spending firms relative to low R&D spending firms.

VI International Comparisons

At this early stage of our research it is possible to distinguish two findings: (1) at a firm level, a relatively better employment performance has been exhibited by R&D performing firms and (2) in a

[21] See Baldwin & Johnson (1995). In this paper the authors note that the major difference between innovating and non-innovating firms is not solely based on their views about technological advances, "they (innovating firms) are more concerned about human resources, markets and products, financing, and management skills and practices."(p34).

sectoral comparison of high tech and low tech industries, the superior employment performance of the high tech sector becomes evident. To what extent do our preliminary findings tally with those of more in-depth micro studies of the link between technology and employment?

Firm Level Aspects

Roper et al (1996) conducted a survey of product innovation in Irish, German and British manufacturing firms. As such it provides the only source to benchmark our results against a similar albeit smaller data set of Irish firms. They find clear differences in the employment growth of innovators and non-innovators for all three countries. In Ireland innovating firms reported an employment growth of 7.1%, while non-innovators grew by 4.6%, over the period 1991-1993. In terms of studies carried out for similar economies, Klette (1995) provides mixed results for Norway when contrasting the employment change for R&D active and Non-R&D active firms. He finds no clear-cut relationship between the R&D intensity of a firm and net job creation. By contrast, Van Reenen (1997:256), using UK data, finds "*a strong positive association"* between innovation and employment at firm level, in line with earlier microeconometric studies which he cites. He argues that the relationship is causal and not merely associative.

Sectoral Level Aspects

The Roper study which included the Irish manufacturing sector did not explore a link between R&D performing firms and employment at a sectoral level. Therefore we benchmark our results in this area to studies completed for Austria and Norway. The evidence, of a superior employment performance for the high tech sectors matched with a decline in employment in the low-tech industries found in our preliminary study has been matched in other studies. Leo et al (1995) note similar findings to ours in their study of innovation and employment at firm level. They note that, in sharp contrast to the available evidence for low and medium tech industries, employment in high tech sectors has increased. They offer the explanation, that *"the employment record of high-tech industries does not answer the question in which new areas new technologies destroy jobs. It may be the case that these technologies are again to blame for the reductions of employment in low and medium-tech industries as they enable more efficient production processes(p.1)"* By contrast Klette (1995) reports a mixed performance for high tech industries in terms of net job creation. For

the case of Norway, Klette has found that while net job creation was evident in the high tech sector in the early 1980's, there was job destruction in the late '80s and early 1990's.

VI Concluding Comments

These preliminary results, which indicate a positive association between R&D commitment and subsequent employment performance at sectoral level, suggest that it is of interest to examine in greater depth the relationship between employment and R&D expenditure at firm level in Ireland, a firm-level econometric analysis is now underway. Such an analysis will allow us to control for several sectoral and firm characteristics that, as is well documented in the literature, turn out to be important (see Stoneman, 1995). These characteristics include: firm size, the age of the firm, the type of research carried out and the orientation of that research (process or product). In addition, we would expect to find that the distinction between foreign and domestic firms will continue to be important.

References

Baldwin, John R & Joanne Johnson (1995) "Business Strategies in Innovative and Non-Innovative Firms in Canada". *Statistics Canada,* Canada.

Belitz, Heike & Marian Beise (1997) "The Internationalisation of R&D in Multinational Enterprises: The German Perspective" presented to the *National Institute of Economic and Social Research,* London.

Braunerhjelm, Pontus & Karolina Ekholm (1997) "Foreign Activities by Multinational Corporations". *Research Institute of Industrial Economics, Sweden*.

European Commission (1991) *Eurostatistics: Data for short term economic analysis, Eurostatistics: Data for short term economic analysis,* Eurostat,12.

European Commission (1997) *Eurostatistics: Data for short term economic analysis, Eurostatistics: Data for short term economic analysis,* Eurostat,6.

Klette, Tor Jakob & Svein Erik Forre (1995) "Innovation and Job Creation in a Small Open Economy: Evidence from Norwegian Manufacturing Plants 1982-92", *Statistics Norway*, No. 159.

Leo, Hannes & Viktor Steiner (1995) "Innovation and Employment at the firm level", *Austrian Institute of Economic Research*

Meghir, Costas, Annette Ryan & John Van Reenen (1995) "Job creation, technological innovation and adjustment costs: Evidence from a panel of British firms", *The Institute for Fiscal Studies Working Paper Series,* w95/6, London.

Odagiri, Hiroyuki & Hideto Yasuda (1996) "The determinants of overseas R&D by Japanese firms: an empirical study at the industry and company levels", *Research Policy,* 25, 1059-1079.

OECD (1996) *Employment Outlook: July 1996*, Paris, OECD.

Peterson, John (1996) "Research and Development Policy". In: Kassim, Hussein & Anand Menon (ed.): *The European Union and National Industrial Policy*. Routledge , London. pp 226-247.

Roper, Stephen et al (1996) "Product Innovation and Development in UK, German and Irish Manufacturing", *Northern Ireland Economic Research Centre.*

Ruane, Frances & Holger Goerg (1997) "The Impact of Foreign Direct Investment on Sectoral Adjustment in the Irish Economy", *National Institute Economic Review*, April 1997, 76-87.

Stoneman, Paul (1995) *Handbook of the Economics of Innovation and Technological Change*, Blackwell, Oxford.

Strobl, Eric & Paul Walsh (1996) "The Aggregate Employment flows in Irish Manufacturing", *Trinity Economic Papers*, Technical Paper No. 3.

Van Reenen, John (1997) "Employment and Technological Innovation: Evidence from U.K. Manufacturing firms", *Journal of Labour Economics*, 15, 255-284.

Vivarelli, Marco, Rinaldo Evangelista and Marco Pianta (1996) "Innovation and employment in Italian manufacturing industry, *Research Policy*, 25,1013-1026.

DATA APPENDIX A

A Description of Absolute Employment Change for the Cohort (≥10 employees in 1986)

Table 5

Irish	Absolute employment change for Non R&D, Small R&D Spenders and Large R&D Spenders for the Cohort.														
	Non R&D Active			**Total R&D Active**			**Small R&D Active**			**High R&D Active**			**Total**		
YEAR	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**
High tech	595	510	-14.3	2765	2407	-12.9	942	678	-28.0	1823	1729	-5.2	3360	2917	-13.2
Med.-High tech	3770	2482	-34.2	4965	5753	15.8	1903	1901	-0.1	3062	3852	25.8	8735	8235	-5.7
Med.-Low tech	9191	6962	-24.3	14757	11859	-19.7	4263	4285	0.5	10494	7574	-27.8	23948	18821	-21.4
Low tech	41871	28490	-32.0	28374	28247	-0.5	9385	8373	-10.8	18989	19874	4.7	70245	56737	-19.2
Totals	55427	38444	-30.6	50861	48266	-5.1	16493	15237	-7.6	34368	33029	-3.9	106288	86710	-18.4

Table 6

Foreign	Absolute employment change for Non R&D, Small R&D Spenders and Large R&D Spenders for the Cohort.														
	Non R&D Active			**Total R&D Active**			**Small R&D Active**			**High R&D Active**			**Total**		
YEAR	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**
High tech	4831	2834	-41.3	9148	14055	53.6	557	820	47.2	8591	13235	54.1	13979	16889	20.8
Med.-High tech	8422	7856	-6.7	13186	16634	26.1	1871	2147	14.8	11315	14487	28.0	21608	24490	13.3
Med.-Low tech	5378	5381	0.1	6677	6449	-3.4	2454	2100	-14.4	4223	4349	3.0	12055	11830	-1.9
Low tech	13082	7647	-41.5	15429	14547	-5.7	2928	2156	-26.4	12501	12391	-0.9	28511	22194	-22.2
Totals	31713	23718	-25.2	44440	51685	16.3	7810	7223	-7.5	36630	44462	21.4	76153	75403	-1.0

A Description of Firm Exit for the 1986 Cohort

Table 7

Irish	The Number of deaths (by 1995) of Irish firms from the 1986 Cohort.														
	Non R&D Active			**Total R&D Active**			**Small R&D Active**			**High R&D Active**			**Total**		
YEAR	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**
High tech	18	11	-38.9	42	30	-28.6	12	8	-33.3	30	22	-26.7	60	41	-31.7
Med.-High tech	158	73	-53.8	103	81	-21.4	58	45	-22.4	45	36	-20.0	261	154	-41.0
Med.-Low tech	361	226	-37.4	158	130	-17.8	104	80	-23.1	54	50	-7.4	519	356	-31.4
Low tech	1103	579	-47.5	234	201	-14.2	148	124	-16.2	86	77	-10.5	1337	780	-41.7
Totals	2177	1426	-34.5	537	442	-17.7	322	257	-20.2	215	185	-14.0	2714	1868	-31.2

Table 8

Foreign	The Number of deaths (by 1995) of Foreign firms from the 1986 Cohort.														
	Non R&D Active			**Total R&D Active**			**Small R&D Active**			**High R&D Active**			**Total**		
YEAR	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**
High tech	39	22	-43.6	62	56	-9.7	11	9	-18.2	51	47	-7.8	101	78	-22.8
Med.-High tech	89	65	-27.0	96	80	-16.7	29	26	-10.3	67	64	-4.5	185	155	-16.2
Med.-Low tech	88	61	-30.7	61	57	-6.6	32	28	-12.5	29	29	0.0	149	118	-20.8
Low tech	125	67	-46.4	60	50	-16.7	27	19	-29.6	33	31	-6.1	185	117	-36.8
Totals	341	215	-37.0	279	252	-9.7	99	81	-18.2	180	171	-5.0	620	467	-24.7

Surviving Firms from the 1986 Cohort

Table 9

Irish	Absolute Employment Change for the Surviving Irish firms from the Cohort.														
	Non R&D Active			**Total R&D Active**			**Small R&D Active**			**High R&D Active**			**Total**		
YEAR	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**
High tech	317	500	57.7	1999	2395	19.8	709	678	-4.4	1290	1717	33.1	2316	2895	25.0
Med.-High tech	1988	2320	16.7	3877	5724	47.6	1199	1876	56.5	2678	3848	43.7	5865	8044	37.2
Med.-Low tech	5984	6792	13.5	14000	11824	-15.5	3604	4250	17.9	10396	7574	-27.1	19984	18616	-6.8
Low tech	26332	27809	5.6	25675	28224	9.9	7899	8350	5.7	17776	19874	11.8	52007	56033	7.7
Totals	34621	37421	8.1	45551	48167	5.7	13411	15154	13.0	32140	33013	2.7	80172	85588	6.8

Table 10

Foreign	Absolute Employment Change for the Surviving Foreign firms from the Cohort.														
	Non R&D Active			**Total R&D Active**			**Small R&D Active**			**High R&D Active**			**Total**		
YEAR	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**	**1986**	**1995**	**% Δ**
High tech	2566	2820	9.9	8707	14042	61.3	420	813	93.6	8287	13229	59.6	11273	16862	49.6
Med.-High tech	7592	7837	3.2	12730	16634	30.7	1734	2147	23.8	10996	14487	31.7	20322	24471	20.4
Med.-Low tech	4379	5347	22.1	6511	6449	-1.0	2288	2100	-8.2	4223	4349	3.0	10890	11796	8.3
Low tech	7863	7629	-3.0	13788	14547	5.5	2473	2156	-12.8	11315	12391	9.5	21651	22176	2.4
Totals	22400	23633	5.5	41736	51672	23.8	6915	7216	4.4	34821	44456	27.7	64136	75305	17.4